IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
Larry C. Olsen et al.
Application No. 10/726,744
Filed: December 2, 2003
Confirmation No. 6833
For: THERMOELECTRIC DEVICES AND APPLICATIONS FOR THE SAME
Examiner: Jeffrey Thomas Barton
Art Unit: 1795
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AMENDMENT

This responds to the Office action dated August 4, 2008. Please amend the referenced application as follows:

Amendments to the Claims are reflected in the listing of claims, which begins on page 2.

Remarks begin on page 7.

Claims

1. (Currently Amended) A thermoelectric power source comprising:

a flexible substrate having an upper surface; and

a plurality of thermoelectric couples with the thermoelectric couples comprising:

(a) a sputter deposited thin film p-type thermoelement positioned on the upper surface of the flexible substrate;

(b) a sputter deposited thin film n-type thermoelement positioned on the upper surface of the flexible substrate adjacent the p-type thermoelement;

(c) an electrically conductive member positioned on the flexible substrate, and electrically connecting the first end of the p-type thermoelement with the second end of the n-type thermoelement, wherein the p-type or the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein *x* and *y* form a non-stoichiometric compound and *x* is about 2 and *y* is about 3; and

wherein the thermoelectric couples are formed on a single substrate and the flexible substrate is in a coil configuration or an accordion configuration.

2. (Currently Amended) A~~The~~ thermoelectric power source ~~of claim 1~~ comprising:

a flexible substrate having an upper surface; and

a plurality of thermoelectric couples with the thermoelectric couples comprising:

(a) a sputter deposited thin film p-type thermoelement positioned on the upper surface of the flexible substrate;

(b) a sputter deposited thin film n-type thermoelement positioned on the upper surface of the flexible substrate adjacent the p-type thermoelement;

(c) an electrically conductive member positioned on the flexible substrate, and electrically connecting the first end of the p-type thermoelement with the second end of the n-type thermoelement, wherein the p-type or the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein and *x* is about 2 and *y* is about 3;

wherein the thermoelectric couples are formed on a single substrate and the flexible substrate is in a coil configuration or an accordion configuration; and

wherein the p-type or the n-type thermoelements have L/A ratios greater than about 500 ~~20~~ cm^{-1}.

3. (Original) The thermoelectric power source of claim 1 wherein the p-type or the n-type thermoelements have L/A ratios greater than about ~~100~~ 1000 cm^{-1}.

4. (Canceled)

5. (Previously presented) The thermoelectric power source of claim 1 wherein the thermoelectric power source has a power output of at least about 1 μW with a voltage of at least about 0.25 volt.

6. (Previously presented) The thermoelectric power source of claim 1 further comprising at least about 50 thermoelectric couples, wherein the thermoelectric power source has a power output of at least about 1 μW with a voltage of at least about 0.25 volt.

7. (Original) The thermoelectric power source of claim 6 wherein the p-type or the n-type thermoelements are at least about 1 mm in length and at least about 0.1 mm in width.

8. (Original) The thermoelectric power source of claim 6 wherein the p-type or the n-type thermoelements are at least about 20 angstroms in thickness.

9. (Original) The thermoelectric power source of claim 1 further comprising at least about 1000 thermoelectric couples, wherein the thermoelectric power source has a power output of about 1W with a voltage of at least about 1 volt.

10. (Previously presented) The thermoelectric power source of claim 1 wherein the p-type thermoelements each have a first width, the n-type thermoelements each have a second width, and the first width is different from the second width.

11. (Original) The thermoelectric power source of claim 1 wherein two or more p-type thermoelements are positioned and electrically connected in parallel with one another and the

parallel positioned p-type thermoelements are electrically connected in series to n-type thermoelements.

12. (Previously presented) The thermoelectric power source of claim 1 wherein the thin film p-type thermoelement and/or the thin film n-type thermoelement are co-sputter deposited thin films comprising Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein x is about 2 and y is about 3.

13. (Original) The thermoelectric power source of claim 1 wherein the volume of the thermoelectric power source is less than about 10 cm^3 and has a power output of from about 1 μW to about 1 W.

14. (Original) The thermoelectric power source of claim 1 wherein the volume of the thermoelectric power source is less than about 10 cm^3 and provides voltages of greater than about 1 volt.

15. (Original) The thermoelectric power source of claim 14 wherein the thermoelectric power source produces power at temperature differences of about 20°C or less.

16. (Original) The thermoelectric power source of claim 1 wherein two or more n-type thermoelements are positioned and electrically connected in parallel with one another and the parallel positioned n-type thermoelements are electrically connected in series to p-type thermoelements.

17. (Original) The thermoelectric power source of claim 1 wherein the n-type thermoelements are substantially free of selenium.

18. (Original) The thermoelectric power source of claim 1 wherein the flexible substrate is a polyimide.

Claims 19 – 22 (Canceled)

23. (Currently Amended) A thermoelectric power source comprising:

~~a flexible substrate having an upper surface;~~

multiple thermocouples electrically connected to one another on ~~the~~ an upper surface of a single flexible substrate, the thermocouples comprising:

sputter deposited thin film p-type thermoelements having thicknesses of 0.1 mm or greater;

sputter deposited thin film n-type thermoelements alternatingly positioned adjacent the p-type thermoelements, the n-type thermoelements having a thickness of about 0.1 mm or greater;

wherein the thermoelectric power source has a volume of less than about 10 cm^3 and has a power output of from about 1 μW to about 1 W generated by the thermocouples on the single flexible substrate; and

wherein the p-type thermoelements or the n-type thermoelements comprise a Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y alloy where x is about 2 and y is about 3.

24. (Previously presented) The thermoelectric device of claim 23 wherein said multiple thermocouples electrically connected to one another are in series-parallel.

25. (Currently Amended) The thermoelectric power source of claim 23 wherein the p-type thermoelements have L/A ratios greater than about ~~20~~ 500 cm^{-1}.

Claims 26 – 36 (Canceled)

37. (Currently Amended) A thermoelectric power source comprising:

a flexible substrate having an upper surface; and

a thermoelectric couple comprising:

(a) ~~a sputter~~ co-sputter deposited alternating thin film p-type and n-type thermoelements positioned on the upper surface of the flexible substrate;

~~(b) a sputter deposited thin film n-type thermoelement positioned on the upper surface of the flexible substrate adjacent the p-type thermoelement; and~~

(be) an electrically conductive member positioned on the flexible substrate, and electrically connecting ~~the~~ a first end of the p-type thermoelement with ~~the~~ a second end of the n-type thermoelement, wherein the p-type or the n-type thermoelements comprise Bi_xTe_y where x is about 2 and y is about 3; and

(cd) wherein the flexible substrate is in a coil configuration.

38. (Previously presented) The thermoelectric power source of claim 37 wherein the p-type thermoelements or the n-type thermoelements are at least about 1 mm in length and at least about 0.1 mm in width.

39. (Previously presented) The thermoelectric power source of claim 37 wherein the volume of the thermoelectric power source is less than about 10 cm^3 and has a power output of from about 1μW to about 1W.

REMARKS

Claims 1-3, 5-18, 23-25 and 37-39 are pending in the present application. Reconsideration is respectfully requested.

1. Claims 23 and 24 are rejected under 35 U.S.C. §102(b) as allegedly being anticipated by DE 297 23 309 U1 (DE '309).

Applicants traverse this rejection because DE`309 fails to teach or suggest at least one element cited in amended claims 23 and 24. DE`309 fails to teach that such thermocouples providing the recited power output wherein the power is supplied by thermocouples that are formed on a single flexible substrate.

Claims 23 and 24 recite a single layer device that achieves the recited power output. Specifically, the claims recite, in part, a thermoelectric power source comprising thermocouples on a single flexible substrate, wherein the thermoelectric power source has a volume of less than about 10 cm^3 and has a power output of from about 1 μW to about 1 W. The claims have been amended to make it even clearer that the recited power output is generated by those thermocouples formed on the single substrate.

The Examiner noted that such a feature is missing in DE`309 in both the present office action and the just previous office action. In acknowledging this missing feature of DE`309 the Examiner states "Due to the open 'comprising' language of the preamble of claim 23, the claims are deemed to be open to additional elements, such as the additional films stacked in the device of Figure 1 of DE '309."

As the Examiner knows, "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987); MPEP §2131. The fact that DE`309 achieves the recited power output in a different manner, not on a single layer, not only means that DE`309 fails to qualify as anticipatory reference, it also is evidence of the non-obviousness of the claimed device. "Even if the prior art device performs all the functions recited in the claim, the prior art cannot anticipate the claim if there is any structural difference." MPEP § 2114.

The presently claimed thermoelement configuration formed on a single flexible substrate allows for optimizing the L/A ratio of the thermoelements within the deposition chamber (advantages of the L/A ratio are discussed in the specification and below). These tailoring abilities based on the single substrate device as claimed provide superior versatility because any internal conducting element can be made in a variety of useful configurations depending upon the ultimate application of the device, such as in a parallel or series bridge to nearby elements before the assembly leaves the deposition chamber thereby providing higher reliability and reproducibility than can be achieved with the DE`309 device.

Because DE`309 fails to teach or suggest such a device, Applicants respectfully request that the rejections of claims 23 and 24 be withdrawn.

2. Claims 1-3, 5-10, 12-15, 17, 18, 23-25 and 37-39 are rejected under §103(a) as allegedly being obvious in view of the combination of Migowski (WO 89/07836) and Buist (4,859,250).

Applicants traverse these rejections for at least the reasons below.

Claim 1 has been amended to recite, in part, a thermoelectric power source comprising a plurality of thermoelectric couples comprising p-type and n-type thermoelements, wherein the p-type or the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein x and y form a non-stoichiometric compound and x is about 2 and y is about 3. Support for the amendment can be found throughout the specification, such as at p. 10, lines 6-10; p. 12, line 28 – p. 13, line 5; Fig. 11 and Examples 1 and 2.

The non-stoichiometric composition of the p-type and n-type thermoelements is obtained by the disclosed co-sputtering methods, which are non-equilibrium processes (see, e.g., p. 12, lines 28-30). Changing parameters and conditions, including the chamber pressure, the substrate temperature, the deposition rate, the power supplied to the targets, and the reactive gas pressure during the co-sputtering of target materials provides the recited non-stoichiometric Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y compositions. Variation of these parameters allows the fabrication of the recited thermoelements having desirable thermoelectric, electric and thermal properties – that is, the non-stoichiometric co-deposits provide thermoelectric power that greatly exceeds that of purely stoichiometric deposits. FIG. 11 illustrates how the electrical conductivity and the Seebeck coefficient vary as the Bi_xTe_y and Sb_xTe_y compositions change.

Migowski neither teaches nor suggests p-type or the n-type thermoelements comprising Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein x and y form a non-stoichiometric compound and x is about 2 and y is about 3. Buist, cited by the Examiner as making up for the deficiencies of Migowski, also fails to teach or suggest p-type or the n-type thermoelements comprising Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein x and y form a non-stoichiometric compound and x is about 2 and y is about 3.

Even if, *arguendo*, a contention that Buist discloses thermoelements comprising Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein x and y form a non-stoichiometric compounds, as recited in amended claim 1 (which it does not) was taken as correct, Buist fails to act as prior art for such a contention because Buist does not enable the making of such thermoelement compositions. **There is no anticipation or prima facie obviousness if there is not also enablement of that for which the art is cited**.

> "In determining that quantum of prior art disclosure which is necessary to declare an applicant's invention 'not novel' or 'anticipated' within section 102, the stated test is whether a reference contains an 'enabling disclosure'... ." *In re Hoeksema,* 399 F.2d 269, 158 USPQ 596 (CCPA 1968). The disclosure in an assertedly anticipating reference must provide an enabling disclosure of the desired subject matter; mere naming or description of the subject matter is insufficient, if it cannot be produced without undue experimentation. *Elan Pharm., Inc. v. Mayo Found. For Med. Educ. & Research*, 346 F.3d 1051, 1054, 68 USPQ2d 1373, 1376 (Fed. Cir. 2003).

Accordingly, claim 1 is allowable over the art of record and withdrawal of the rejection is respectfully requested.

Claim 2 as amended recites, in part, a thermoelectric power source comprising, in part, sputter deposited thin film p-type and n-type thermoelements, wherein the p-type or the n-type thermoelements have L/A ratios greater than about 500 cm^{-1}. (Support for this amendment is in the specification at, e.g., p. 4, lines 15-16.) Neither Migowski nor Buist teach or suggest such an L/A ratio.

The L/A ratios are critical parameters of the claimed devices and such criticality is disclosed in the present application. As stated in specification, Applicants determined through testing that a key parameter affecting the voltage produced by the thermoelements is the length-to-area (L/A) ratio of the individual thermoelements, where A is the cross sectional area of a thermoelement. Applicants provide particular L/A ratios so to achieve a design power output at a large enough voltage to be directly applicable to intended particular devices needing power,

without having to provide voltage amplification. The L/A ratios and dimensionalities taught by Applicants critically govern the difference between acceptable and non-acceptable output of a desired method/device. As such, the choice of L/A ratio clearly is not merely a dimensions choice but has extensive effect on the resulting voltage produced by the power source.

Neither Migowski nor Buist nor any other reference of record, teach or suggest such L/A ratios or even recognize the importance of such a ratio and as such, claim 2 is not obvious and is allowable over the art of record.

Claims 3, 5-10, 12-15, and 17-18 are allowable for at least the same reasons as set forth in regard to claims 1 and 2.

Claim 23-25 as amended recite, in part, a thermoelectric power source comprising multiple thermocouples electrically connected to one another; the thermocouples comprising sputter deposited thin film p-type and n-type thermoelements having thicknesses of about 0.1 mm or greater. (Support for this amendment can be found throughout the specification such as at p. 10, lines 14-16.)

As noted by the Examiner, Migowski discloses much thinner (by orders of magnitude) thermoelements (p. 4, layer thickness of 0.005 mm) and asserts that the layers be as thin as possible. Buist does not disclose a layer thickness at all – completely failing to recognize the importance of this parameter. Furthermore, neither reference teaches or suggests how to achieve such thicknesses – prior art must be enabling to be considered to teach or suggest a feature.

The thicknesses of the thermoelement as recited in the presently claimed device is critical to the operation of the device as the thermoelement thickness, along with other parameters of the thermoelement, determines the ultimate TE power source output. Thicker deposits allow the design of higher power output devices than was ever possible with prior art devices, while maintaining desired L/A ratios such that the thermoelectric, electric and thermal properties of the device are also optimized for the ultimate application of the TE power source device.

Accordingly, claims 23-25 are allowable over the art of record.

Claims 37-39 as amended recite, in part, a thermoelectric power source comprising co-sputter deposited alternating thin film p-type and n-type thermoelements positioned on the upper surface of a flexible substrate. Nothing in Migowski or Buist teach or suggest co-sputter deposited thermoelements.

The Examiner states that the process by which the claimed apparatus is made is not relevant as the process does not further define the structure of the claimed device. This statement is incorrect. It is the co-sputtering deposition processes (which are non-equilibrium processes) that give the p-type and n-type thermoelements a non-stoichiometric chemistry. (See, e.g., p. 12, lines 28-30). That is, the parameters and conditions, including the chamber pressure, the substrate temperature, the deposition rate, and the electric power delivered to each target and the reactive gas pressure during the co-sputtering of target materials provides the non-stoichiometric Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y compositions. As such, the structure of the claimed device is different from that disclosed in the cited references.

"The structure implied by the process steps should be considered when assessing the patentability of product-by-process claims over the prior art, especially where the product can only be defined by the process steps by which the product is made, or where the manufacturing process steps would be expected to impart distinctive structural characteristics to the final product." MPEP § 2113, citing, *In re Garnero*, 412 F.2d 276, 279, 162 USPQ 221, 223 (CCPA 1979). Because the structure recited in claims 37-39 is necessarily different from the prior art due to the recitation in claims 37-39 of co-sputter deposited thermoelements, claims 37-39 are allowable over the art of record.

Claim 38 recites the thermoelectric power source of claim 37 wherein the p-type thermoelements or the n-type thermoelements are at least about 1 mm in length and at least about 0.1 mm in width. Neither Buist nor Migowski teach or suggest such dimensioned thermoelements. The Examiner asserts that such dimensions are merely a design choice – this contention is incorrect. As stated above, Applicants determined through extensive testing that a key parameter affecting the voltage produced by the thermoelements is the length-to-area (L/A) ratio of the individual thermoelements. Accordingly, Applicants provide particular L/A ratios so to achieve a design power output at a large enough voltage to be directly applicable to intended particular devices needing power, without having to provide voltage amplification. As such, the choice of L/A ratio (and hence the length and width parameters) clearly is not merely a

dimensions choice but has extensive effect on the resulting voltage produced by the power source. None of the prior art teaches or suggests such a device nor even recognizes the effects of such parameters on the resulting device. Accordingly, in addition to the reasons set forth above in relation to claim 37, claim 38 is allowable over the art of record for this reason as well.

3. Claims 11 and 16 are rejected under §103(a) as allegedly being obvious in view of the combination of Migowski, Buist and Bass (US 6,207,887).

The Claimed Combination is Improper

The Examiner acknowledges that Migowski does not disclose the claimed series-parallel configuration. Bass is cited by the Examiner as allegedly making up for this deficiency in Migowski. This proposed combination is improper as the Bass referenced feature (the series-parallel configuration) could not be combined with Migowski to produce an operable device for providing power as recited in the claims of the present application or even as disclosed in Migowski.

Bass discloses a series-parallel connection using monolithic block and/or wafer construction separated by a plurality of insulating separating layers. That is, it is a large 3-dimensional device with multiple layers 4 of alternating p-type and n-type thermoelements separated by insulating layers of Kapton. (See, e.g., Col. 6, lines 6-14, and lines 53 through Col. 3, lines 62; Figs. 1 and 6 – shown herein).

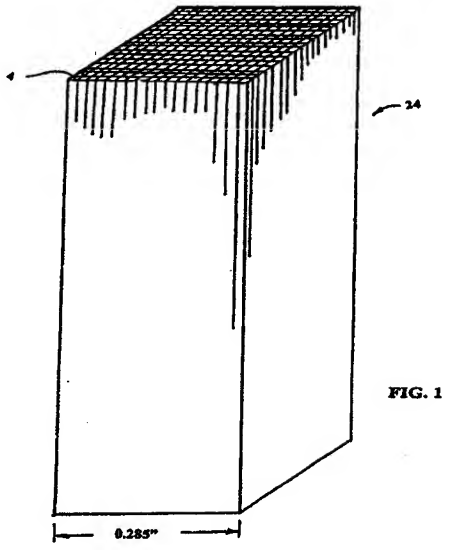

FIG. 1

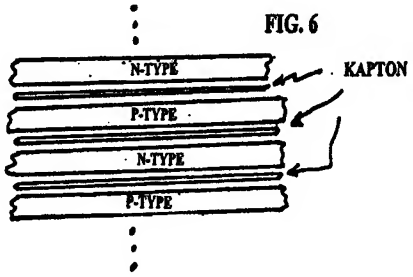

FIG. 6

The Migowski device is essentially a 2-dimensional power device formed on a thin substrate wherein the p-type and n-type thin film elements are formed thereon and connected to one another in series via overlap of a portion of each thin film (p. 2, 3rd full para.; p. 2, last para.; Figs. 2 and 4 shown herein). Migowski states that the substrate and thin films are manufactured to be rolled up for use in small devices, such as watches (p. 3, last sentence of carry over para. of p. 2).

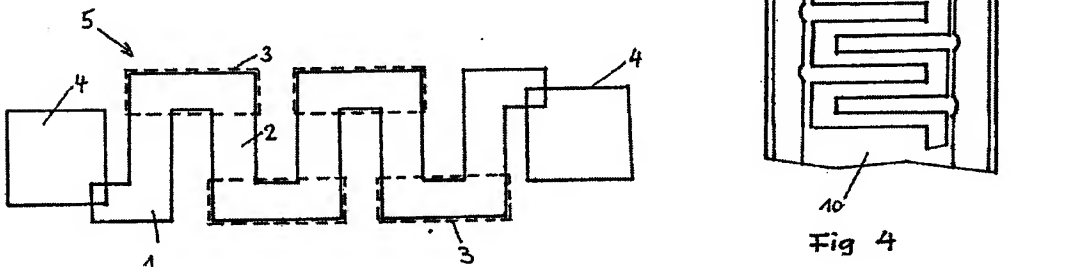

Fig 4

The Examiner states that it would have been obvious for one of ordinary skill in the art to modify Migowski with the series-parallel connections taught by Bass. Applicants respectfully disagree.

As the Examiner knows, for such a holding of obviousness the combining of prior art elements according to known methods must yield predictable results. "[I]t can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does." *KSR International Co. v. Teleflex Inc.*, 82 USPQ2d 1385, 1396 (2007). If any of these findings cannot be made, then this rationale cannot be used to support a conclusion that the claim would have been obvious to one of ordinary skill in the art. MPEP § 2143.

In the present case, no one of ordinary skill in the art would have attempted to combine the monolithic (three-dimensional) block series-parallel approach of Bass with the flat (two-dimensional) Migowski device to come upon Applicants' claimed method and device and nothing in either reference indicates such a combination would be possible or would yield predictable results. The mere fact that references can be combined or modified (which does not

even appear to be likely between Migowski and Bass) does not render the resultant combination obvious unless the results would have been predictable to one of ordinary skill in the art. *KSR*, at 1396 (2007). MPEP § 2143.01.

Accordingly, for the reasons set forth above, claims 11 and 16 are allowable over the cited art. In addition, claims 11 and 16 are allowable over the art of record for the reasons set forth above in relation to claim 1.

4. Claims 23-25 are rejected under 35 U.S.C. §103(a) as allegedly being obvious in view of Stark (2004/0231714).

Although Applicant disagrees that the Stark publication makes obvious the subject claims, submitted herewith is the previously filed Declaration Under § 1.131 now including the signature of all four inventors. Thus, the Stark publication is not available as prior art, and the rejection is now moot.

5. Claims 1-3, 5-10, 12-15, 17, 18 and 37-39 are rejected under §103(a) as allegedly being obvious in view of the combination of Stark and Barr (U.S. 4,036,665).

Although Applicant disagrees that the Stark publication makes obvious the subject claims, submitted herewith is the previously filed Declaration Under § 1.131 now including the signature of all four inventors. (Previously, one of the inventors was out of the country and not able to be contacted.) Thus, the Stark publication is not available as prior art, and the rejection is now moot.

6. Claims 11 and 16 are rejected under §103(a) as allegedly being obvious in view of the combination of Stark, Barr and Bass.

Although Applicant disagrees that the Stark publication makes obvious the subject claims, submitted herewith is the previously filed Declaration Under § 1.131 now including the signature of all four inventors. Thus, the Stark publication is not available as prior art, and the rejection is now moot.

Request for Interview

If any issues remain, the Examiner is hereby formally requested to contact the undersigned attorney prior to issuance of the next Office Action in order to arrange a telephonic interview. It is believed that a brief discussion of the merits of the present application may expedite prosecution. This request is being submitted under MPEP § 713.01, which indicates that an interview may be arranged in advance by a written request.

Respectfully submitted,

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